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FINAL REPORT

Contract Title: Adaptive Grid Methods for Numerical Weather Prediction

Principal Investigators: Joseph Oliger and Robert L. Street

Contracting Institution: Stanford University, Stanford, CA

Funding Agency: Office of Naval Research

Contract Number: N00014-84-K-0267

Contract Period: 1 March 1984 through 31 December 1988



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Summary of Accomplishments:

The major objective of this project was to develop automatic adaptive grid methods for numerical weather prediction based upon computed error estimates. We began with the adaptive grid system developed at Stanford by Oliger and Berger for problems in two space dimensions and with a developmental hydrostatic primitive equation weather constructed by Tim Hogan at NEPRF. The adaptive grid system was extended to three space dimensions and the data structures of the Hogan model were modified and a solver was developed for use with the adaptive grid system. Computational experiments were successfully carried out with this system for a barotropic cyclone and an unstable baroclinic jet with horizontal refinement. The primitive hydrostatic equations were demonstrated to be inadequate for use with vertical refinement and the equations derived by Browning and Kreiss for meteorological applications were incorporated into the model and shown to reproduce the earlier results with horizontal refinement. These results are reported on in the paper by Oliger, Skamarock and Street (1989) and in the Ph. D. Thesis of Skamarock (1986). We then developed an interpolation method to preserve to near hydrostatic balance of the atmosphere for use with vertical refinement. A report on this work is in preparation and this method is proposed to be used in further work for mesoscale phenomena with ONR.

We have also carried out several supporting investigations in the course of this work. We have developed an accelerated Schwarz iteration for solving elliptic equations on adaptive grid structures for the initialization calculations needed in meteorology. This work is reported on in the paper of Oliger, Skamarock and Tang (submitted for publication) and in the Ph. D. Thesis of Tang (1987). We have also investigated open boundary conditions for use with limited area forecasts. This work is reported on in the two papers by Gustafsson (1987a, 1987b).

Journal Articles:

Submitted:

Joseph Oliger, William Skamarock and Wei-Pai Tang, Convergence analysis and acceleration of the Schwarz alternating method(submitted to SIAM J. on Scientific and Statistical Computing).

B. Gustafsson, Far field boundary conditions for time-dependent hyperbolic systems.

B. Gustafsson, Inhomogeneous conditions at open boundaries for wave propagation problems.

Published:

Joseph Oliger, W. Skamarock and R.L. Street, Adaptive Grid Refinement for Numerical Weather Prediction, J. Comp. Phys., 80, 27-60 (1989).

Books Published:

Joseph Oliger, Algorithm design for computational fluid dynamics on parallel machines, High Speed Computing, R. Wilhelmson ed., U. Of Ill. Press, 94-96 (1988).

Ph.D. Theses:

Wei-Pai Tang, Schwarz Splitting and Template Operators, Stanford University, 1987.

William Skamarock, Adaptive Grid Refinement for Numerical Weather Prediction, Stanford University, 1987.

Patents Filed:

None

Patents Granted:

None

Invited Presentations:

Joseph Oliger:

Scientific Applications and Algorithm Design for High Speed Computing Workshop,
University of Illinois, Urbana, IL, 7-10 April 1986.

International Congress on Computational and Applied Mathematics, University of
Leuven, Belgium, 21-26 July 1986.

Numerical Methods Symposium of Defense Nuclear Agency, SRI, Menlo Park, CA, 28-
29 April 1987.

SIAM Minisymposium on Methods for Compressible Fluid Computations, Denver, CO,
13 October 1987.

Wei-Pai Tang:

SIAM Meeting on Parallel Computation, Los Angeles, CA December 1987.

Contributed Presentations:

William Skamarock:

AGU Meeting, San Francisco, CA, January 1988.

Technical Reports:

J. Oliger, W. Skamarock and W.-P. Tang, Convergence analysis and acceleration of the
Schwarz alternating method, CLaSSiC Manuscript 86-12, Dept. of Computer Science,
Stanford Univ., 1986.

W. Skamarock, J. Oliger and R.L. Street, Adaptive grid refinement for numerical weather

prediction, CLaSSiC Manuscript 87-15, Dept. of Computer Science, Stanford Univ.,1987.

W. Skamarock, Adaptive grid refinement for numerical weather prediction, CLaSSiC Report 87-05, Dept. of Computer Science, Stanford Univ.,1987.

B. Gustafsson, Far field boundary conditions for time-dependent hyperbolic systems, CLaSSiC Manuscript 87-16, Dept. of Computer Science, Stanford Univ.,1987.

B. Gustafsson, Inhomogeneous conditions at open boundaries for wave propagation problems, CLaSSiC Manuscript 87-19, Dept. of Computer Science, Stanford Univ.,1987.

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